Generalized Optional Locking in Distributed Systems

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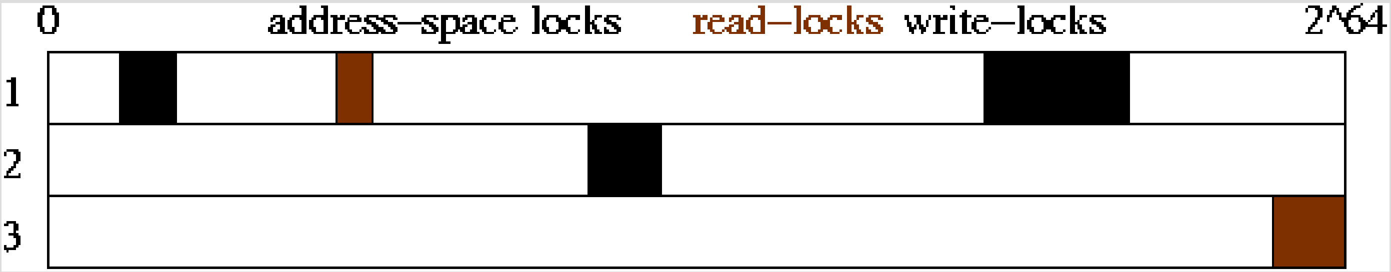
Outline

- Problem: mutual exclusion
  - *very slow* in distributed systems (esp. fine-grained)
  - most distributed systems try to avoid / circumvent it
  - efficient solution => uniform programming models
- Idea: exploit *spatial locality* of locks
  - 2 kinds of locks: obligatory / optional
  - *negotiate* the *size* of optional locks dynamically (in difference to *hierarchical* locking)
- Performance Study => high speedups possible
- Further Result: communication paradigm is special case of optional locking
- Future work / Conclusions

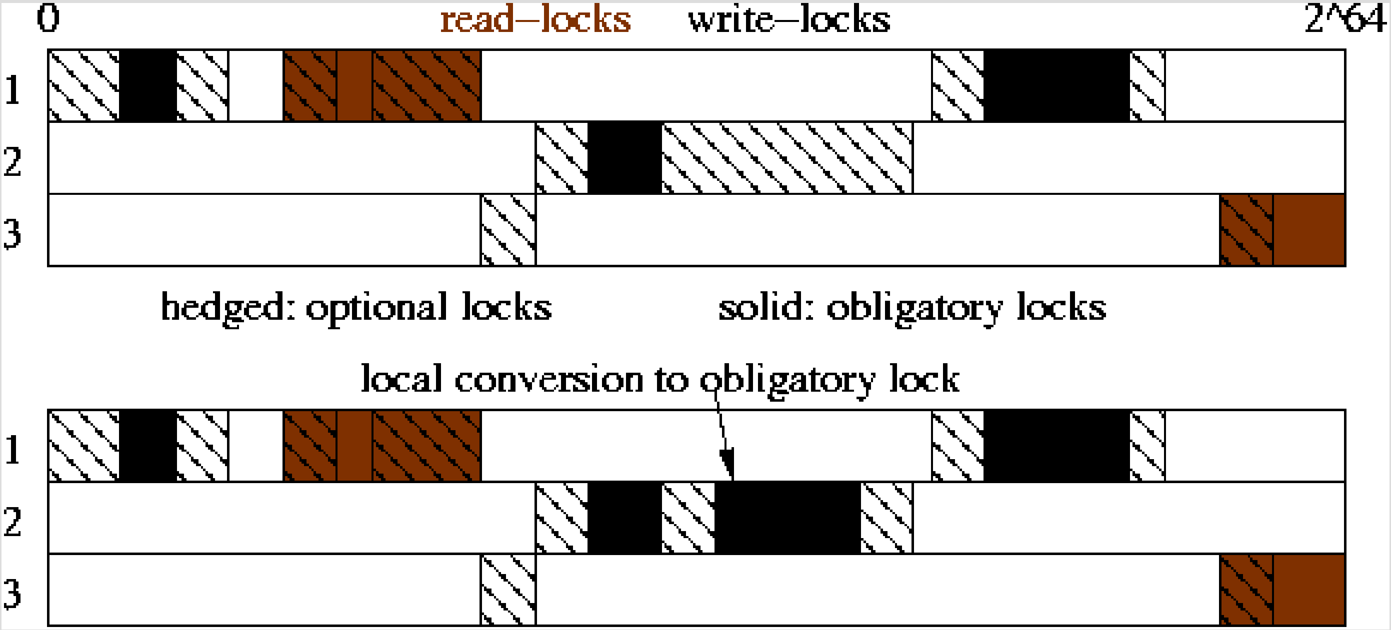
Preparation



- Don't use substitute objects, e.g. semaphore
- Issue lock requests *directly* on the memory region occupied by a data object
  - similar to Unix `lockf()` or `fcntl()` locking
  - characterized by (startaddress,length,locktype)
- => **locality of access** behavior translates to locking *directly*

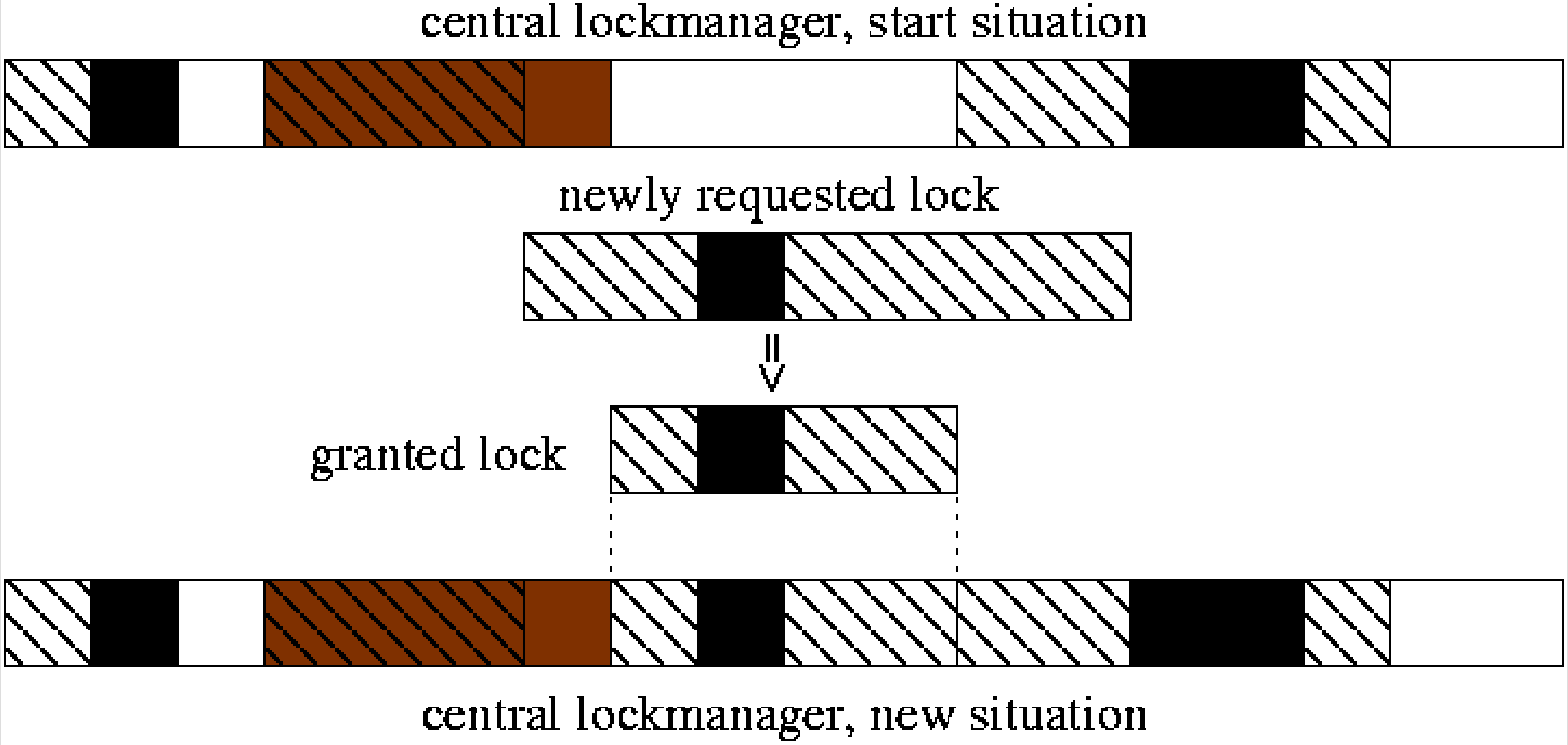
Optional Locks

- 2 types: obligatory / optional
- Optional lock is *locally convertible* to obligatory lock at any time, no network traffic

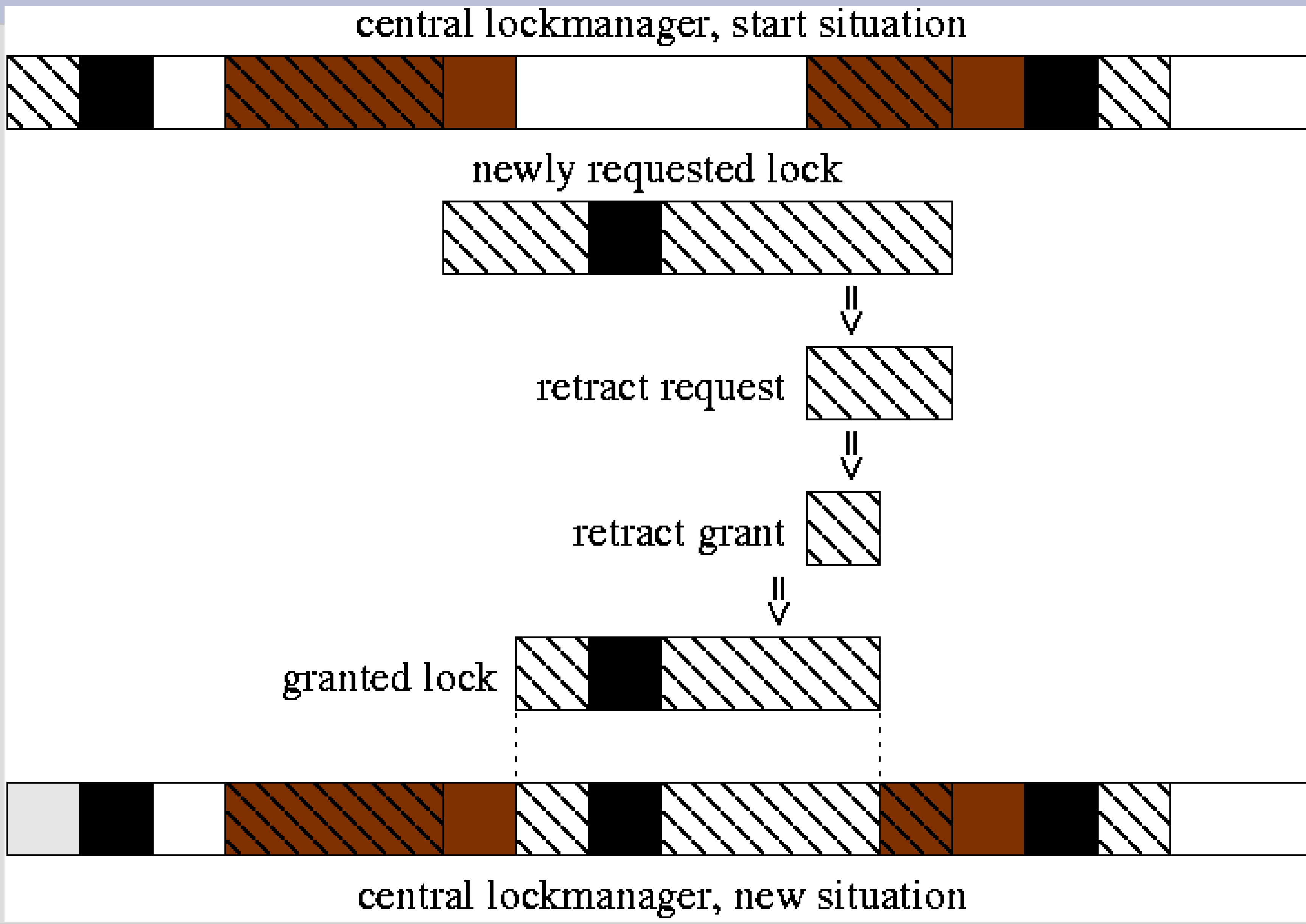


Negotiation of Optional Locks

Scenario: central lockmanager



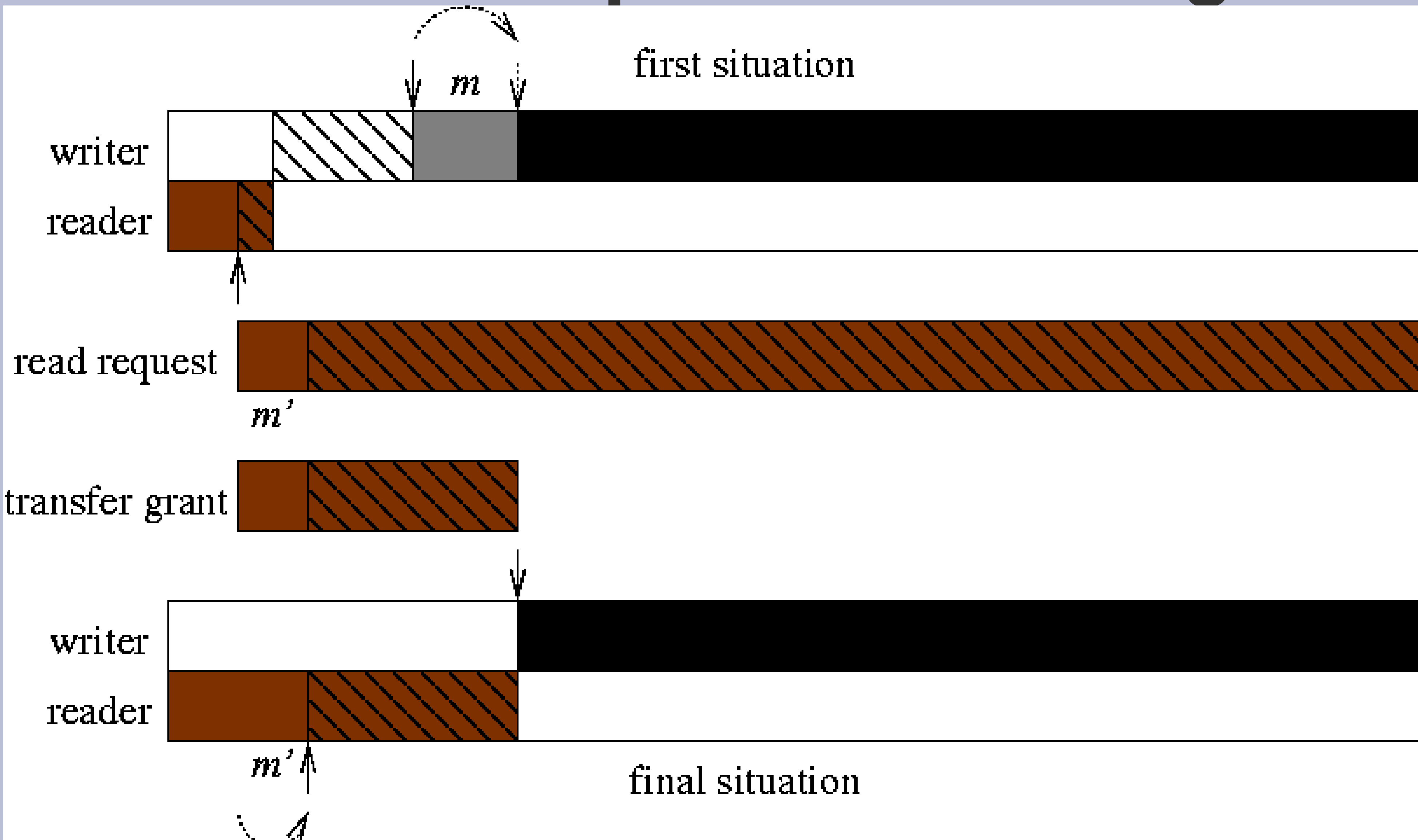
Retraction of Optional Locks



Performance Study

- Experiments: TPC-like database benchmarks on PostgreSQL => observed locking patterns
- Simulator: distribute n server threads to $m \leq n$ virtual network sites, count # of lock/retract requests for different negotiation strategies
- Results: speedup factors from ~30 to ~180 (speedups relative to known obligatory lock prefetching/caching: from ~0.93 to ~5.4)
- More details => paper

Message Passing as Special Case of Optional Locking



Consequences

- Message Passing paradigm is a special case of optional locking
- Merged optional locks correspond to coalesced messages
- => efficient solution of both mutual exclusion and message passing is *possible* in uniform way
- Bridging the bottleneck of Distributed Systems no longer “special”?
- Distributed Shared Memory (DSM) should be *reconsidered* (when combined with optional locking)

Future Work

- *Symmetric* optional locking (no central server)
- Reliability, failure resilience, security, ...
- New applications, formerly unsuitable for distributed computing?
- Practical experience ... (a lot missing)
  - Distributed databases?
  - Distributed operating systems / middleware: Athomux prototype => meta-middleware based on LEGO principle ==> www.athomux.net
  - High-performance / cluster computing
  - Other ideas => contact me

Contribution / Conclusions

- Automated negotiation of locking *granularities*
- High speedups for mutual exclusion
- Emulation of message passing, probably of other synchronization scenarios
- => uniform programming models possible
- Details, client-server algorithm + proof
  => paper, www.athomux.net
- Further research necessary
  e.g. negotiation strategies, thrashing prevention, practices...